THE SIGNATURE OF THREE HEAVY NEUTRAL LEPTONS
PREDICTED BY MAGNETIC QUARK THEORY, IS FOUND
IN THE ENERGY DISTRIBUTION OF TAU-DECAY PARTICLES
(EXTRACT FROM THEORETIC PAPERS, No. 3, 1985)

by

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Methods to identify the structure and calculate the masses of the best known elementary particles, inclusive baryons, mesons and even leptons, by magnetic monopole theory are developed in recent years (Barricelli, N.A.: Theoretic Papers No. 2, 1983). The procedure is basically the same which is used in the calculation of atomic energy levels. But instead of dealing with electrical Coulombian fields, we deal with magnetic fields by taking into account field modifications of a kind expected when the distance between charges is smaller than their classical radius.

It is of paramount importance for the theory's acceptance, being able to predict undetected elementary particles and forecast their masses and other properties. The theory predicts the existence of three neutral leptons, namely a neutral myon μ_0 of mass 106 MeV, a strange lepton S_0 of mass 296 MeV and its higher energy version S_T' of mass 425 MeV (a less probable version might have the mass 452 MeV instead of 425 MeV, Barricelli, N.A.: Preprint Series No 6, Applied Math., University of Oslo, 1979. Barricelli, N.A.: Theoretic Papers, No. 5, 1983. Gimse and Kolset: Theoretic Papers, Vol. 1, No. 2, 1984). What appears to be the signature of these three new particles is now found in the decay products of the TAU-lepton.

TAU is a recently discovered elementary particle, which is unstable and within ca. 10^{-13} seconds decays into several elementary particles of lower mass. The decay products include a neutral lepton usually designated as a TAU-neutrino. Its mass is usually assumed to be low and possibly comparable to that of other neutrinos. Various attempts to find an upper limit to its mass have been published; the latest one by Matteuzzi and his coworkers (1984, SLAC-PUB-3291, LBL-17415).

Since the masses of neutral leptons can not directly be measured by any available instrument, indirect methods are usually applied. The method used by Matteuzzi et al consists in selecting TAU-decay events yielding, beside the TAU-neutrino, also four π mesons, whose energies can be measured. The energy distribution of the four π mesons (measured by their invariant mass $M_{4\pi}$ distribution), which can be obtained by measuring a large number of events (see fig.1), is dependent on the mass of the neutral lepton and can be used in order to evaluate this mass. The method seems straightforward if one could trust that the 5 particles, four π mesons and one neutral lepton, are produced directly by the decaying TAU-particle. There are data machine programs which, in this case, can calculate the expected $M_{4\pi}$ distribution for every possible mass of the neutral lepton. On this hypothesis (designated as "the direct decay hypothesis") it would be sufficient to calculate by a data processing machine the expected 4π energy distributions obtained by several possible selections of the mass ascribed to the neutral lepton. Any expected distribution, showing a good fit to the observed 4π distribution, would help identifying the mass of the neutral lepton.

There are, however, also other possibilities which must be taken into account. For example a TAU-decay could occur in two steps. In the first step the TAU-particle might decay into 2 particles, namely a heavy meson called ρ', and a neutral lepton. In a second step ρ' would usually decay into four π mesons. This possibility, designated as "ρ' resonance hypothesis" is apparently consistent with the TAU-neutrino hypothesis, and has been considered the more likely one (see fig. 1, diagram A).

We decided to give a closer look at the results one may obtain by applying the less popular direct decay hypothesis. We had a hunch that, at least in some cases, instead of a TAU-neutrino of insignificant mass one might find one of the three neutral leptons predicted by the magnetic quark theory. The data machine program needed in order to calculate these theoretical distributions was not immediately available. Because of the disorganization created by the elimination of punched card programs, it took

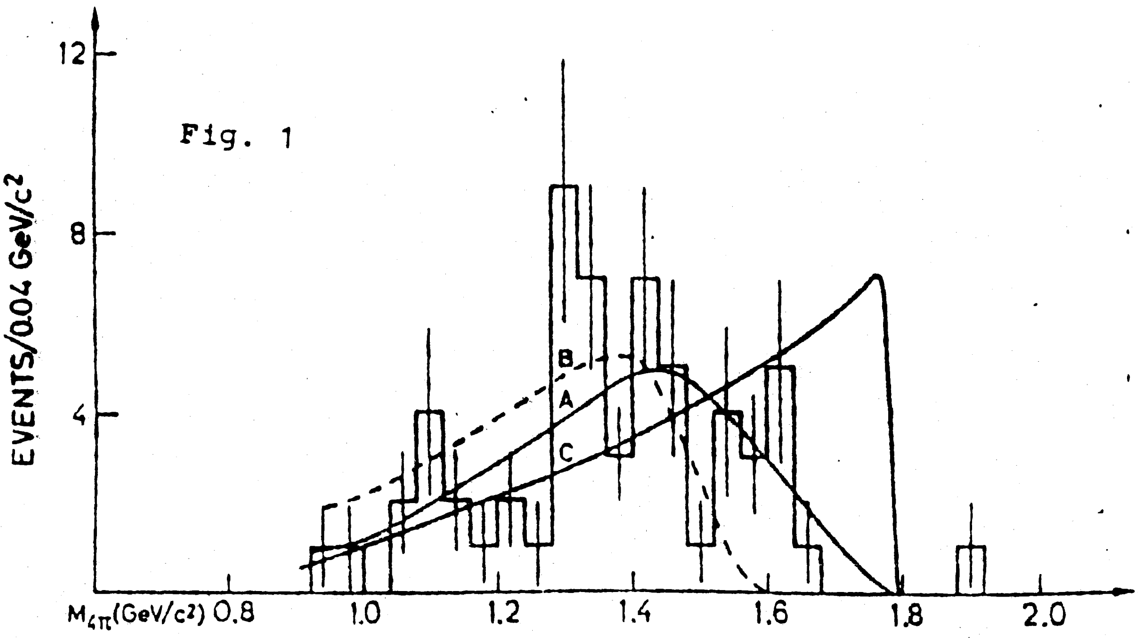
6 months to retrace the wanted machine program. It was an exciting experience to watch the $M_{4\pi}$ distributions delivered by the data machine. Each distribution has a characteristic very pronounced maximum value, which would be expected to appear in the experimental distribution if the corresponding neutral lepton were present in a significant portion of the TAU-decays instead of a TAU-neutrino.

There are indeed three very pronounced maximum values in the experimental $M_{4\pi}$ distribution (fig. 1). With the best precision obtained in the experiment, each one of them coincides with a top value (fig. 2) predicted for one of the three neutral leptons listed above. Moreover, there is no maximum value at the position expected for a neutral lepton of mass close to zero (fig. 1, diagram C) as one might have expected if there were a TAU-neutrino of insignificant mass.

These results, if confirmed by later experiments, would seem to put the Matteuzzi et al $M_{4\pi}$ distribution in a completely new light. Its three prominent maximum values could no longer be dismissed as statistical fluctuations, as one could have done before these coincidences were detected. They are, more likely, the signature of the three neutral leptons predicted by the magnetic quark theory, and the direct decay hypothesis would appear to be valid for a substantial portion of the TAU-decays involved in the Matteuzzi et al experiment.

These results raise many new questions which need additional experimental and theoretical work before they can be answered. Experimental confirmation both by repeating the Matteuzzi et al experiment and by other means is needed before the existence of the three theoretically predicted neutral leptons can be definitively established. Theoretic work in order to find out how the respective neutral leptons, particularly the neutral myon μ_0 can be formed in a TAU-decay process, is also required.

If the result is confirmed it will have far reaching implications for elementary particle theory and for the problems related to the origin of matter in the universe (Gimse, Theoretic Papers No. 2, Volume 3, 1985).



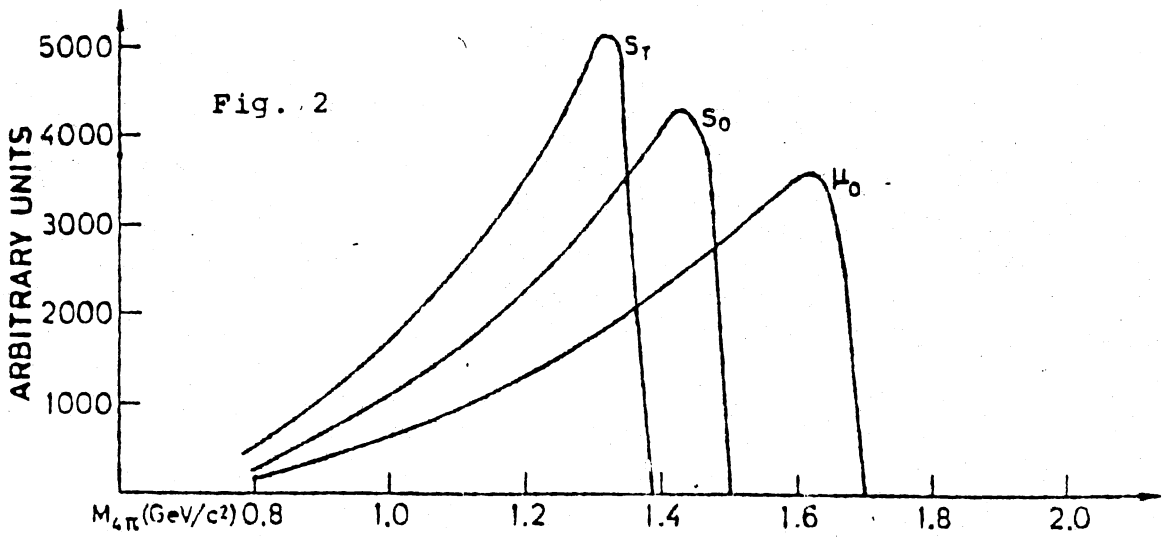


Fig. 1. Experimental distribution of $M_{4\pi}$ invariant mass obtained by Matteuzzi et al in the TAU-decay process $\tau \to 3\pi^{\pm}\pi^{0}\nu_{\tau}$. The theoretic diagrams A and B are calculated on the ρ' resonance hypothesis for a neutral lepton of mass equal to 0 (solid line A) and for a mass of 250 MeV (dashed line B). The diagram C is calculated on the assumption that the direct decay hypothesis is correct for a neutral lepton of mass equal to 0. Fig. 2. Three theoretical diagrams based on the direct decay hypothesis for a neutral lepton of mass 425 MeV (S_T), 296 MeV (S_0) and 106 MeV (μ_0).